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Field Evaluation Of A Television Bore Hole Telescope

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16. ABSTRACT
In January of 1966, an evaluation of the potential use of the Eastman International Television Bore Hole Telescope FB400 in foundation investigations was undertaken by the Materials and Research Department of the California Division of Highways. An engineering geologist was assigned to carry out the field work and make the evaluation. The first portion of this study was conducted along proposed Road 07-LA, Ven-118 in Santa Susana Pass. The second and final portion of the study was conducted eleven miles north of Yreka on Anderson Grade, Road 02-Sis-05 and in the City of Yreka on a section of the same road.

The television Bore Hole Teelescope is trailer-mounted (photo 1 of Appendix) and produces a continuous picture of the walls of a borehole doen to a maximum depth of 1250 ft. Planar features exposed on the walls of the borehole can be measured and the inclination or drift of the boring can be determined at any desired point. Photographs taken of the projected picture on the television screen serve as a permanent record along with a written log of salient features examined during the run.

The television Bore Hole Telescope was used a total of ten days. January 17, 18, 19, 27 and 28, 1966, were spent on the Santa Susana job, while March 28, 29, 30, 31 and April 1, 1966, were required for the Anderson Grade and Yreka Study. An evaluation was made of the bore hole TV equipment as an additional tool to aid in the determination of suitable cut slope designs and as a means of obtaining additional information for rippability studies.

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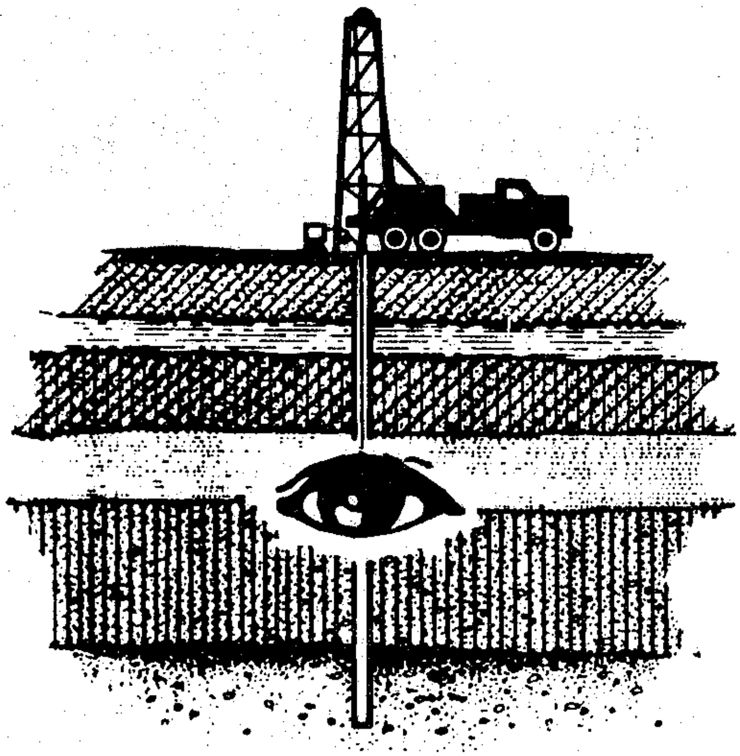
FIELD EVALUATION of a TELEVISION BORE HOLE TELESCOPE



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STATE OF CALIFORNIA

BUSINESS AND TRANSPORTATION AGENCY

DEPARTMENT OF PUBLIC WORKS

DIVISION OF HIGHWAYS

MATERIALS AND RESEARCH DEPARTMEN

RESEARCH REPORT

NO. M & R 226468

Prepared in Cooperation with The U.S. Department of Commerce, Bureau of Public Roads July, 1966

State of California
Department of Public Works
Division of Highways
Materials and Research Department

July 25, 1966

HPR-1(3) F-7-82
Lab Auth 226468

Mr. J. C. Womack
State Highway Engineer
Division of Highways
Sacramento, California

Dear Sir:

Submitted for your consideration is:

FINAL REPORT

of

FIELD EVALUATION

of the

EASTMAN INTERNATIONAL TELEVISION

BORE HOLE TELESCOPE FB400

Study made by .... Foundation Section
Under general direction of .... Travis Smith
Work supervised by .... D. O. Tueller
M. L. McCauley
Report prepared by .... Duane D. Smith

Very truly yours,

J. L. Beaton mu

JOHN L. BEATON
Materials and Research Engineer

Attach

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Acknowledgements

The Foundation Section of the Materials and Research Department conducted this study. The work was done under the 1965-66 Work Program HPR-1(3) F-7-82 in cooperation with the U.S. Department of Commerce, Bureau of Public Roads. The equipment required to accomplish the field portion of the program was provided by the Department of Water Resources under an Interagency Agreement. Two technicians were provided by the Department of Water Resources for operation of the equipment.

Introduction

In January of 1966, an evaluation of the potential use of the Eastman International Television Bore Hole Telescope FB400 in foundation investigations was undertaken by the Materials and Research Department of the California Division of Highways. An engineering geologist was assigned to carry out the field work and make the evaluation. The first portion of this study was conducted along proposed Road 07-LA,Ven-118 in Santa Susana Pass. The second and final portion of the study was conducted eleven miles north of Yreka on Anderson Grade, Road 02-Sis-05 and in the City of Yreka on a section of the same road.

The Television Bore Hole Telescope is trailer-mounted (photo 1 of Appendix) and produces a continuous picture of the walls of a borehole down to a maximum depth of 1250 ft. Planar features exposed on the walls of the borehole can be measured and the inclination or drift of the boring can be determined at any desired point. Photographs taken of the projected picture on the television screen serve as a permanent record along with a written log of salient features examined during the run.

The television Bore Hole Telescope was used a total of ten days. January 17, 18, 19, 27 and 28, 1966, were spent on the Santa Susana job, while March 28, 29, 30, 31 and April 1, 1966, were required for the Anderson Grade and Yreka Study. An evaluation was made of the bore hole TV equipment as an additional tool to aid in the determination of suitable cut slope designs and as a means of obtaining additional information for rippability studies.

Results and Conclusions of Evaluation

This evaluation study indicates that use of the Eastman International Television Bore Hole Telescope FB400 is feasible as a tool for obtaining data for the design of cut slopes and for other foundation investigations. Maximum value from the employment of this tool can only be achieved, however, when used as a supplement to core samples, drill logs and surface geology.

It appears that the cost of drilling operations could be reduced somewhat by coring at intervals of 20 or 25 ft., followed by examination of the entire boring with the camera probe. Extensive flushing of the bore hole with a mixture of Zimite and water is necessary to remove the mud cake from the walls. Some difficulty in obtaining a clean hole was experienced where loss of circulation did not permit return of the flushing fluid.

The television equipment is best suited in foundation investigations where problems of jointing, fracturing, or orientation of bedding planes are involved such as on Anderson Grade. In materials such as the massive sandstones of Santa Susana Pass, little additional information was gained over that provided by geological mapping of the surface and the core samples taken.

There are several limitations in the use of the television equipment. Broken rock projecting into the bore hole may bind the camera probe resulting in its loss or prohibiting a complete logging of the bore hole. In addition, the mud slurry usually developed in the bottom of the hole after the flushing operation obscures the walls from view.

Because of the complex electronic equipment used, a technician trained in the mechanics of operation should also be versed in the field repair of each component. Replacement parts for the equipment must be ordered from Germany where it is manufactured. Shipment, even by air freight, is time consuming and costly. The operational instruction booklet is lacking in detail and there is no information supplied by the manufacturer on trouble shooting. In addition, there is no field representative in the United States thus requiring correspondence for the solution of any problems which may arise.

Maneuverability of the trailer-mounted equipment was poor. Several of the borings were not accessible to the equipment because of tight turns, poor traction on loose surfaces or steep grades. It is our opinion that a truck van would be more satisfactory for transporting the equipment to the drill sites.

Interpretation of the image on the screen is difficult at times because of the restricted area viewed and the subtle textural and compositional changes which occur as the probe is moved up or down the boring. To gain the maximum benefits from the use of this equipment it is essential that the person in charge have a professional background in both engineering and geology.

The Department of Water Resources is currently using their equipment less than 50 percent of the time. An Interagency Agreement for rental of their equipment could be made.

Projects requiring the use of this type of equipment would be somewhat limited at this time or in the near future and in our opinion would not justify the purchase of similar equipment or the training of personnel to operate it.

The cut slope design work had been completed on the Anderson Grade project prior to the bore hole television study. In general the slopes of this project were designed on a 3/4:1 ratio with some exceptions at specific locations. Some local failures were anticipated, along with some rock fall and slope raveling during and after construction. It does not appear economically feasible to flatten the slopes enough to overcome either of these problems.

Results of the television logging agrees with the anticipated local failures, rock fall and slope raveling. This is particularly true within the large proposed cut near Boring R-4. Joints, open fractures and highly sheared material was viewed from near the surface to about 142 ft. where further logging was not possible because of broken rock projecting into the boring.

Little additional information for cut slope design was provided by the logging of borings of the massive sandstone of Santa Susana Pass, beyond that already supplied by surface geology and drill cores.

Description of the Bore Hole Television Equipment

The Television Bore Hole Telescope FB400 consists of these basic components; the television probe, the control desk with monitoring unit, modulator unit and electrical power supply, the water proof cable and cable winch, and the depth measuring device.

The most important component of the entire system is the television probe (photo 2) which is lowered into the bore hole on a cable and which transmits a picture of the bore hole wall and any measured values of planar features to the operator above ground. The outside diameter of the probe is 2½ in., while its length is 4 ft. 7 in. The housing is designed to withstand an outside pressure of up to 750 psi, the greatest possible hydrostatic pressure of a bore hole 1250 ft. deep completely filled with water.

Portions of the bore hole wall are illuminated by incandescent lamps which transmit light through the panorama glass window. The image of the bore hole wall is then reflected onto the objective of a Mini camera by an elliptic mirror and transmitted to the monitoring screen through the cable. Orientation of the mirror is achieved when light is transmitted through two slits, one located in the north direction of the underlying compass and the other in the lower portion on the mirror. When the alignment of the two slits is accomplished, a beam of light will appear in the center of the television screen. The circular scale on the control desk is then zeroed on north, and all bearings of planar features are referenced to the scale and can be read directly. The accuracy of the readings is approximately one degree in regard to the direction of the mirror and ½ degree in regard to the inclination of the hole, according to the manufacturer.

The television screen (photo 3) or monitoring unit and other electronic gear can be either truck or trailer-mounted. The screen with a diagonal dimension of 7 inches produces an enlarged view of the bore hole wall by about twice its actual size. Good resolution is obtained by using a 620 line Resistron tube. A camera bracket mounted below the TV screen enables the operator to photograph important features shown on the TV screen by using any standard camera with a portrait lens. The transistorized control desk and major electrical components such as the adapter, voltage stabilizer, and modulator unit are mounted on vibration damping rubber-bonded metal to avoid shock during transport of the vehicle over rough ground.

The bore hole probe is connected to the control desk by a 35 conductor cable which is water proof and has a tensile strength of approximately 1100 lbs. This cable is placed on a large winch located in the rear of the trailer for storage and ease of handling (see photo 4). Sufficient cable must be removed from the winch prior to entering the bore hole with the probe as a plug contact is used as a connector to the winch drum. The manufacturer states that a slip ring take-off from the drum is not practical.

The cable is run over a large depth measuring wheel which provides enough friction to keep the cable from slipping. Each complete revolution of the hand-operated, worm-driven crank lowers or raises the probe in the bore hole 2 inches. The depth is automatically recorded on the control panel in the trailer. Communications between the operator of the depth measuring device and the operator of the control panel in the trailer is provided by a 2-way telephone.

Evaluation Program

Santa Susana Pass

The study initially consisted of one field project located on Road 07-LA,Ven-118, in Santa Susana Pass northwest of Los Angeles. Materials consisted predominantly of massive coarse-grained sandstone with some bedded sandstone, interbedded clay lenses, and shales.

Five borings were examined with the camera probe; R-5, R-7, R-8, R-10 and R-15. Boring depths ranged from 100 to 120 ft. Depths of TV logging was in all cases less than the drilled depth because of bridging of the holes and also accumulation of mud slurries in the lower portions which obscured the walls.

Quik-Gel drilling mud was used as a circulating media for all borings. Core samples of the material were taken continuously in some borings and at intervals in others with both Longyear and Christensen core barrels using both diamond and carboloy bits. Permanent loss of circulation was experienced on Borings R-7, R-10 and R-15. All borings except R-5 were flushed with a mixture of water and Zimite, a deflocculating agent, after completion of the drilling operations. Difficulty was experienced in eliminating the mud cake from the walls because loss of circulation in some cases prevented a return of the flushing fluid containing the Zimite.

Logging with the TV probe began on January 17, 1966, at Boring R-5. Shortly after passing the water table at 38 ft., water entered the camera probe causing a short circuit and damaging the Vidicon camera tube and electric motor which rotates the mirror. An external plug which had been removed to pre-adjust the focusing mechanism was inadvertently not replaced and water entered the probe. Operations were stopped for a day while field repairs were made. Work was then continued with the completion of R-5 and R-7. The quality of the television picture was greatly impaired due to permanent damage to the tube, and became progressively worse. Operations were consequently stopped on January 19, 1966, and the equipment was moved to the Department of Water Resources facilities in Bakersfield for more extensive repairs and replacement of the Vidicon tube and motor.

Photographs taken of borings R-5 and R-7 are of poor quality and little information was gained to supplement boring logs and core samples. Boring R-5 was heavily caked with mud.

Television logging operations resumed at Boring R-10 on January 27, 1966. The walls of the boring were coated with a thick mud cake and displayed a well developed alligator pattern of mud cracks above the water table (see photo 5). All detail below the water table was lost in the mud slurry (photo 6). Essentially no additional information was obtained by use of TV equipment on this boring. Loss of circulation prevented the effective use of the Zimite treatment.

Boring R-8 was also logged on January 27, 1966, to a depth of 88 ft. Boring walls were free of mud and a reasonably good picture was obtained. Minor clay lenses interbedded with coarse-grained, fractured sandstone were observed at various levels in the upper portion of the hole (see photos 7 and 8). The drill log indicated a loss of circulation at 43 ft. A large, nearly vertical fracture was observed intermittently from about 37 ft. to its lower termination at 42.7 ft. (photo 9). Circulation was again lost while drilling from 49 to 54 ft., apparently along a near-vertical fracture (see photos 10 and 11). A live beetle was observed on the wall at a depth of 52.4 ft. (photo 12) and was attempting to crawl out of the hole.

Drill hole R-15 was examined with the TV equipment on January 28, 1966, to a depth of 96.4 ft. Walls of the boring were free of mud permitting an unobstructed view of laminated sandstone, shale beds and textural changes within the massive sandstone bed (photos 13, 14 and 15).

Circulation was lost while drilling at 25.5 ft. and 87.5 ft. Large fractures and accompanying voids were observed on the boring walls (see photos 16, 17 and 18) at these levels. Lightweight organic debris was observed foating on the surface of the water table at 90 ft. (photo 19).

Anderson Grade and Yreka

The second and final phase of the Television Bore Hole Telescope field evaluation consisted of an examination of three bore holes on Anderson Grade, located approximately eleven miles north of Yreka, and two borings within the City of Yreka. Both sites are along the proposed realignment of Road 02-Sis-05.

Five borings in Yreka were flushed with Zimite and water on March 29, 1966, in preparation for logging operations. In addition, Boring R-6 on Anderson Grade was logged on the same day to a depth of 114 ft. Materials consisted of jointed and fractured greenstone (see photos 20, 21 and 22). An increase in the frequency of jointing was noted below 101 ft., with some healing of fractures with $CaCO_3$ throughout the entire boring (see photo 23).

Boring R-5 was logged to a depth of 174 ft. on March 30, 1966. Seepage of water along fractures and joints of the greenstone was observed with the camera from approximately 67 ft. down to the water table located at 128 ft. (photo 24).

A ½-inch quartz vein in sheared and slickensided greenstone (photo 25) was noted at 29.8 ft. and was verified by the boring log. Numerous fractures and joints were observed in the boring, a large portion of which have been healed with $CaCO_3$ (photos 26, 27, 28, 29 and 30). Mud cake was evident in the upper portion of the bore hole, photo 31.

The trailer-mounted television equipment was moved to Boring R-4 on March 31, 1966. The hole was logged to a depth of approximately 142 ft. where further penetration of the probe was impeded by broken rock projecting into the hole. Moderately large open fractures (photos 32 and 33) were noted in the upper portion of the boring. The frequency of fractures increased with depth but in general were not as open. Amygdules of calcite in greenstone were photographed at 82.6 ft., and a ½-inch circular fracture healed with calcite was observed at 141.8 ft. (see photos 34 and 35).

The afternoon of March 31, 1966, was spent logging District 02 Borings 79 and 80 in the City of Yreka. Materials consisted of sheared and weathered serpentine characterized by nearly vertical foliation with numerous intersecting joints. The joints appear to be filled with clay or gouge-like material, particularly in severely sheared zones (photos 36 and 37).

The quality of the photographs on the Yreka field trip were generally poor and became progressively worse toward the end of the job due to electronic difficulties in the camera probe and monitoring screen. Photos 38 and 39 show a distinct grid pattern resulting from electronic "noise."

General Observations and Comments

Accuracy of Depth Measurements

Each ½-inch movement of the cable energizes an electric contact so that the depth is shown on the depth indicator with this accuracy. In practice, however, slippage of the cable over the depth measuring wheel can occur, particularly when rapid movement of the camera probe, or a rapid change in direction of the probe is made. The most severe discrepancy in depth measurement observed on this project was at Boring R-5 in Santa Susana Pass where the depth to water table was recorded at 33 ft. with the measuring device. A check of this level was made with an "M-scope" and was measured at 37.8 ft., a difference of 4.8 ft. Displacement of water by the lower 33 inches of the probe, slippage of the cable, and possible operator error in making the initial depth calibration prior to logging may have caused this discrepancy.

Later checks of a similar nature indicated an agreement of within .5 ft. It is our opinion that greater accuracy in measurement of depths can be obtained with increased familiarity with the equipment.

Measurement of Planar Features

As indicated in the section of this report dealing with the description of equipment, the manufacturer states that the accuracy of the readings is approximately one degree in regard to the bearing or direction of the mirror, and ½ degree in regard to the inclination of the hole.

Surface measurements were taken at the Santa Susana site with a Brunton Compass of the dipping sandstone beds adjacent to Boring R-15. A 5-degree variance was noted for the strike of three individual bedding planes measured, while the dip varied by approximately 12 degrees. Subsurface measurements were highly variable and differed from the surface measurements by as much as 90 degrees. Surface geological information indicated that the attitudes of the beds in the area were essentially uniform and would not vary greatly with depth. The cause of this wide range in measurements is not fully understood. It is hoped that the differences can be resolved in future field evaluations or general field use.

Interpretation of TV Data

Sandstone in the Santa Susana Pass area commonly weathers from a hard blue relatively fresh sandstone to a soft friable brown sandstone. This change in degree of weathering is characterized on the TV screen by a subtle shading effect from a moderately dark gray to a somewhat lighter gray. An inexperienced operator or observer could easily miss this subtle change in shading.

Textural changes or changes in grain size of the massive sandstone are frequently indistinct on the monitoring screen and may remain unobserved unless the change is rather abrupt such as in photo 15. It is quite helpful to have the core samples at the drill site when the television logging is done so that frequent correlations can be made between the actual sample and the picture on the screen.

Lithologic changes such as thin shale beds and clay lenses intercalated with the sandstone were generally distinctive and could be readily observed on the screen (see photo 14) when the boring walls were free of mud.

Voids, fractures and joints are perhaps the most striking in appearance on the monitoring screen (see photos 7, 9, 18 and 37). Close correlation was obtained between loss of circulation noted on the boring logs and the presence of extensive fracturing and associated voids for both the Santa Susana and Yreka sites.

Seepage of ground water along clay seams and fractures above the water table can be observed and pin-pointed as to depth and direction of the source of water. Of the five borings logged at the Santa Susana site seepage was noted only in boring R-8 at the base of a vertical fracture located 39.7 ft. below ground surface. The ground water level can be measured and recorded on the TV log as well as by other methods. Pictures taken below the water table are generally inferior to those taken above the water because of the refraction of light in water and diffusion resulting from suspension of solid particles in water.

In our opinion professional training in both engineering and geology is required for the person who does the logging of materials and their particular characteristics, features, and attitudes in order to obtain the maximum information from the use of TV logging equipment. As previously stated, subtle changes in weathering texture, grain size, bedding and lamination can be easily overlooked by a technician trained in the physical operation of the logging equipment but unfamiliar with the geological aspects of the materials logged. Boring logs and cores of the hole logged are extremely helpful in interpretation of the image on the monitoring screen.

Permanent Records

At the time of the field evaluation, permanent records of the logging operations consisted of black and white photographs of the image on the monitoring screen and a written log consisting of descriptions of the photos taken and measurements of planar features. Since the field work has been completed, the Department of Water Resources has purchased an Ampex video tape recorder, microphone and separate monitoring screen for use with the original equipment. The addition of this equipment will enable them to record any portion of the logging operation desired and then at a later time play back the image on the monitoring television screen as it was originally viewed. In addition, a sound recording of pertinent facts or descriptions can be placed on the tape in the field or in the laboratory at a later date. These features will greatly enhance the usefulness of the tool and will provide a permanent record which is far superior to still photographs.

Transportability

The Eastman International Television Borehole Telescope used for this evaluation was mounted in a custom built tandem trailer having an overall length of approximately 19 ft. A 3/4-ton four-wheel drive pickup was used to pull the trailer to the drill sites. As the field work progressed, it became quite evident that the combined length of trailer and pickup was too great for maneuverability on narrow, steep, winding drill roads. Some borings were not logged because of small drill pads which did not allow sufficient room to turn the equipment around, steep, unsurfaced roads with poor traction and turns which had a turning radius too short for the truck and trailer to master.

Equipment of this type would be more portable if mounted in the van of a truck.

APPENDIX

List of Photographs

1. Eastman International Television Bore Hole Telescope FB400
2. Camera probe, depth measuring wheel and cable
3. Monitoring screen and control panel
4. Removing cable from winch
5. Alligator pattern in mud cake
6. Water table
7. Fracture and void in sandstone
8. Clay lens in sandstone
9. Void and fracture in sandstone
10. Vertical fracture in sandstone
11. Large void in sandstone
12. Beetle on wall of boring
13. Laminations in sandstone
14. Shale bed in sandstone
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17. Fracture and voids in sandstone
18. Large void in sandstone
19. Water table
20. Mud cake
21. Parallel fractures in greenstone
22. Fractured greenstone
23. Fractures healed with $CaCO_3$
24. 45° fracture in greenstone
25. ½ inch quartz vein
26. Healed fractures in greenstone

27. Large open fracture
28. Fracture in greenstone
29. $CaCO_3$ filled fracture
30. Circular fracture
31. Mud cracks
32. Large open fractures in greenstone
33. Jagged fracture in greenstone
34. Amygdules of $CaCO_3$ in greenstone
35. ½-inch calcite vein
36. Clay seams in sheared serpentine
37. Clay seams and joint in serpentine
38. Large cavity in serpentine
39. Electronic difficulties

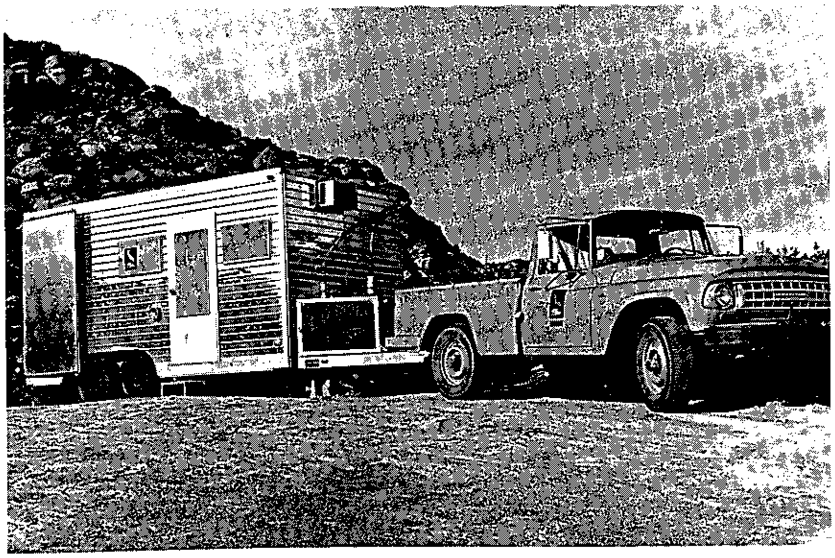


Photo 1 - Trailer-mounted Eastman International Television Bore Hole Telescope FB400.

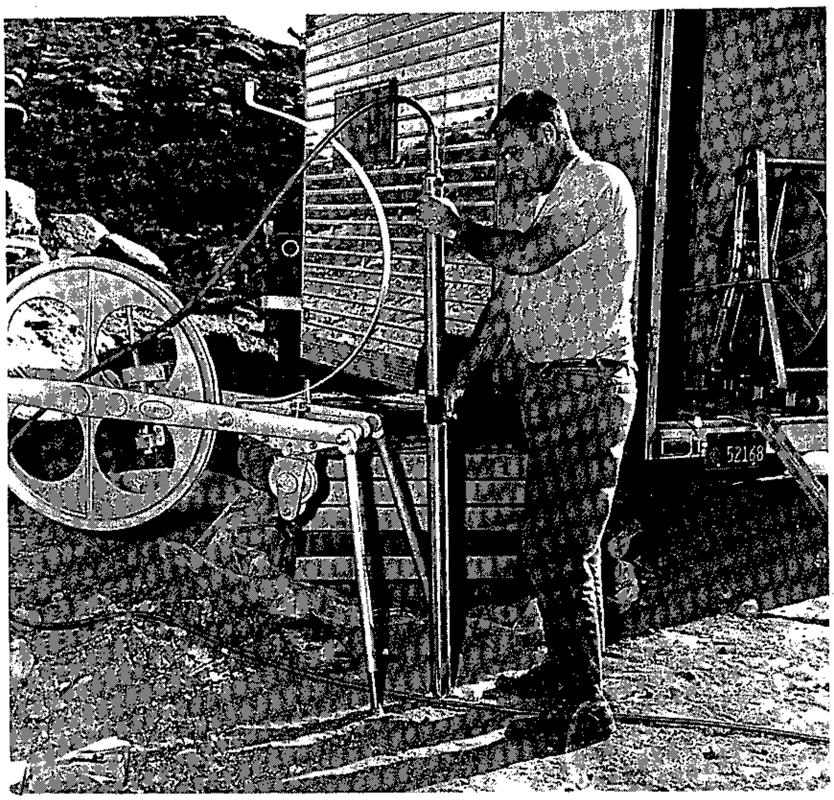


Photo 2 - Placement of cable on depth measuring wheel prior to lowering camera probe in hole.

Photo 3 - Monitoring screen and control panel, in operation.

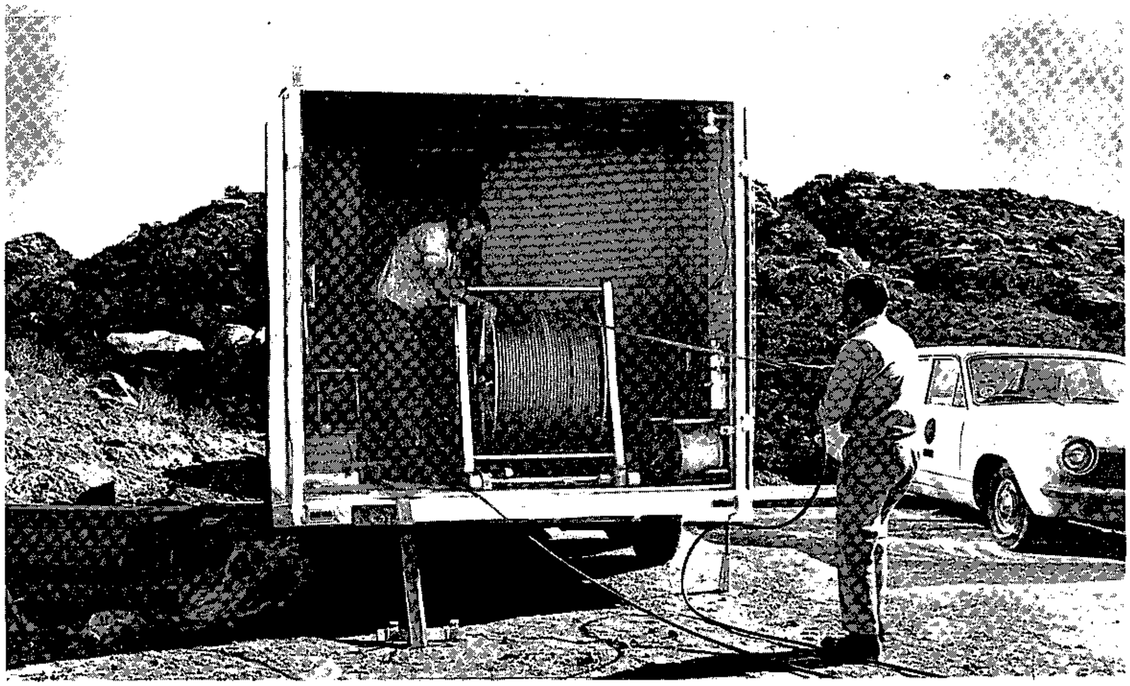


Photo 4- Removing cable from winch mounted in rear of trailer.
Note core boxes at Boring R-5, Santa Susana Pass.

Photo 5 - Boring R-10 Santa Susana Pass. Alligator pattern in mud cake on boring wall, 61.5 ft.

NOTE: Arrow points to bottom of hole.

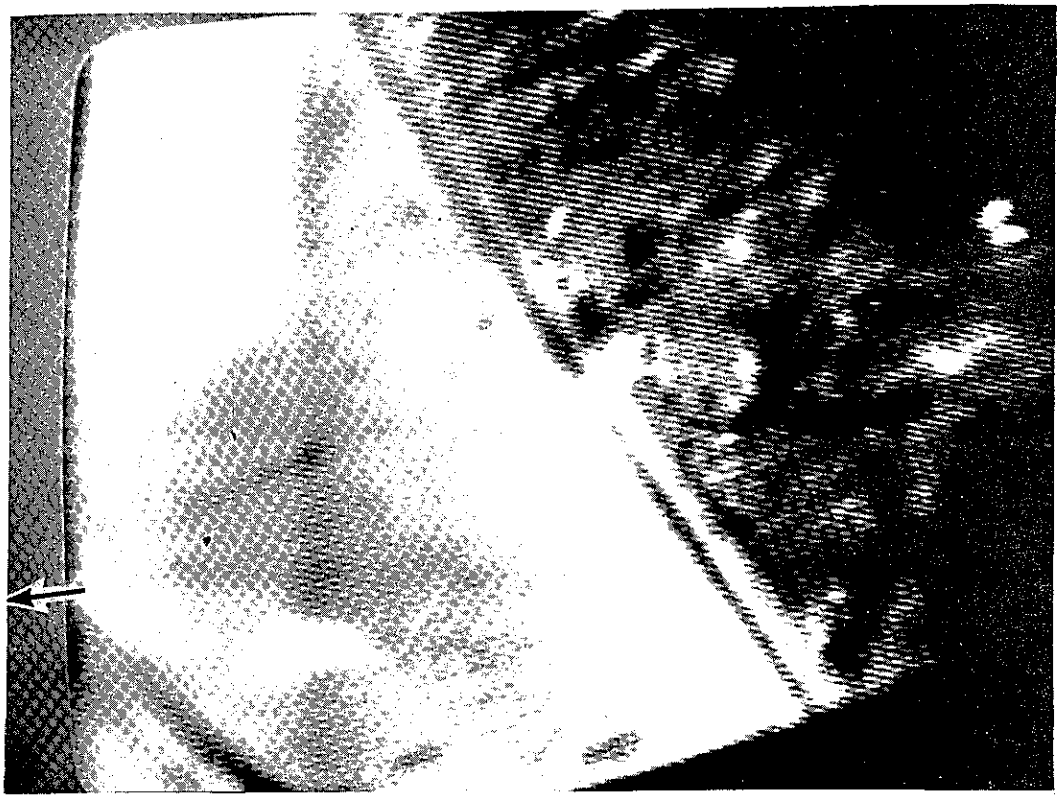
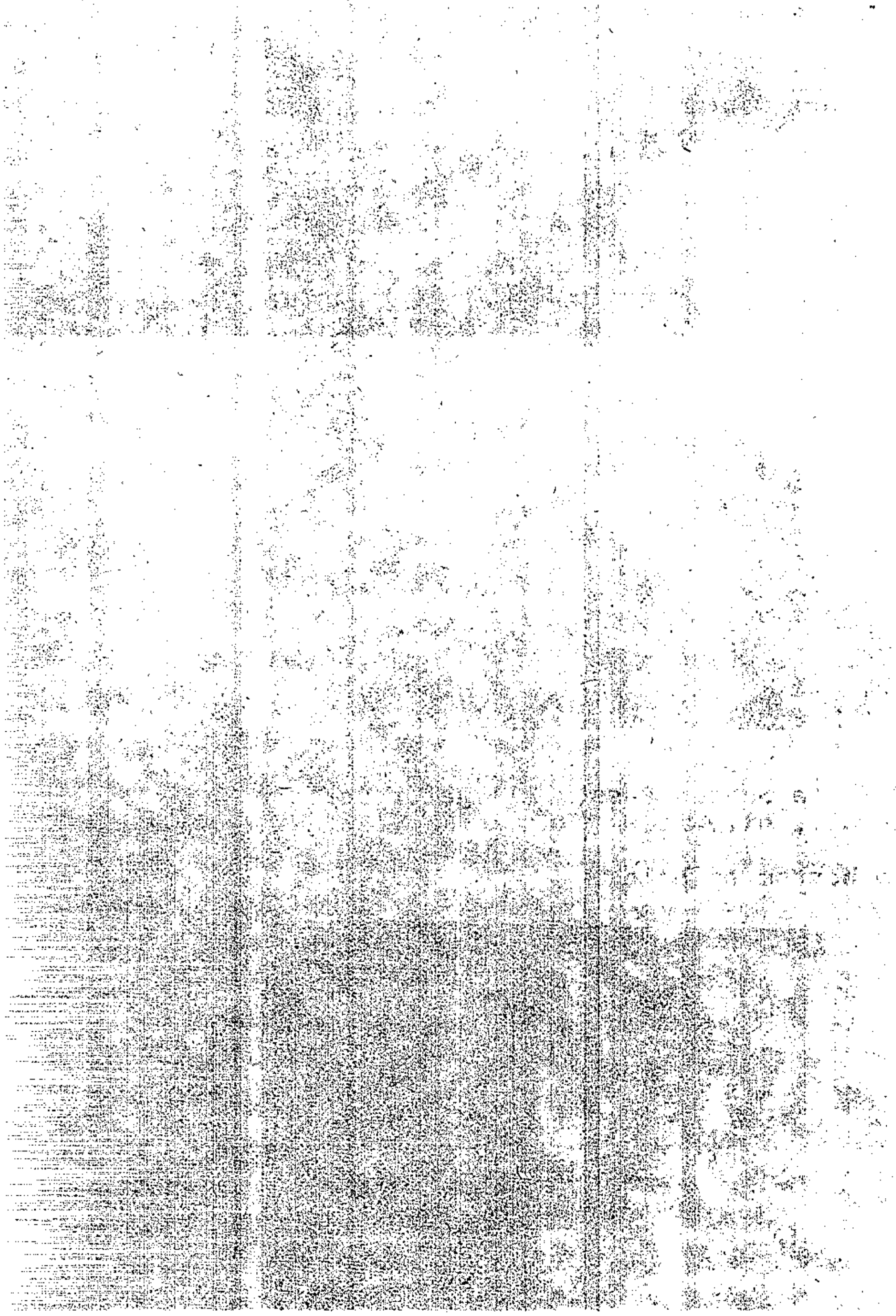


Photo 6 - Boring R-10 Santa Susana Pass 76.8 ft. Water table (light area). Mud slurry obscures boring wall.



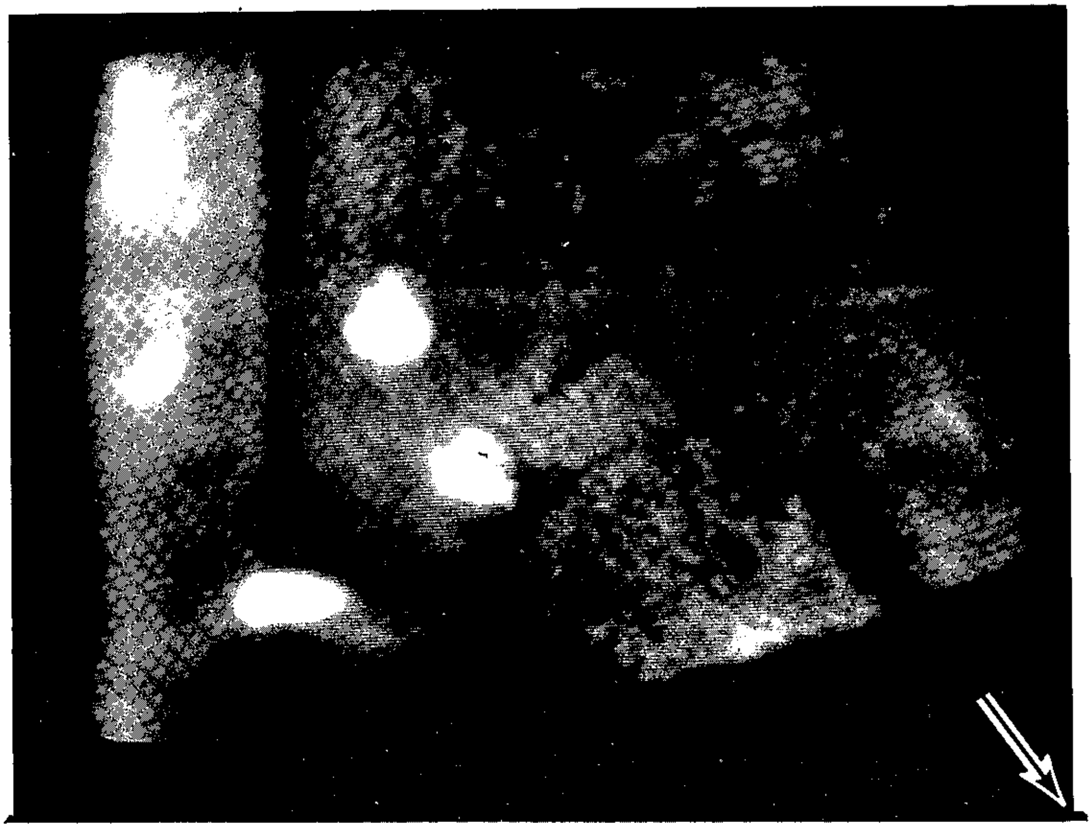


Photo 7 - Boring R-8 Santa Susana Pass 13.4 ft. Due east. Fracture and small void in sandstone. Average with about .12".

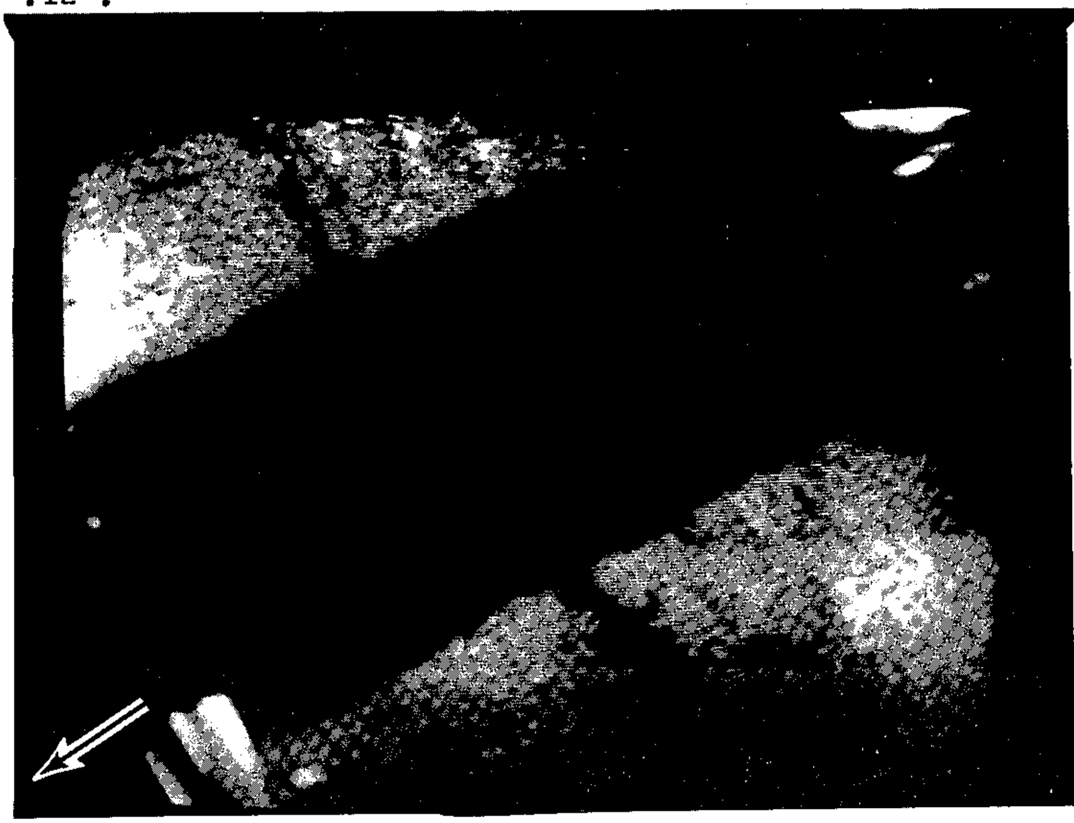


Photo 8 - Boring R-8 Santa Susana Pass 13.2 ft. Clay lens in sandstone, about 1/16 inch wide. Strike N62W, dip 30°W. Wide dark band is shadow of camera post.

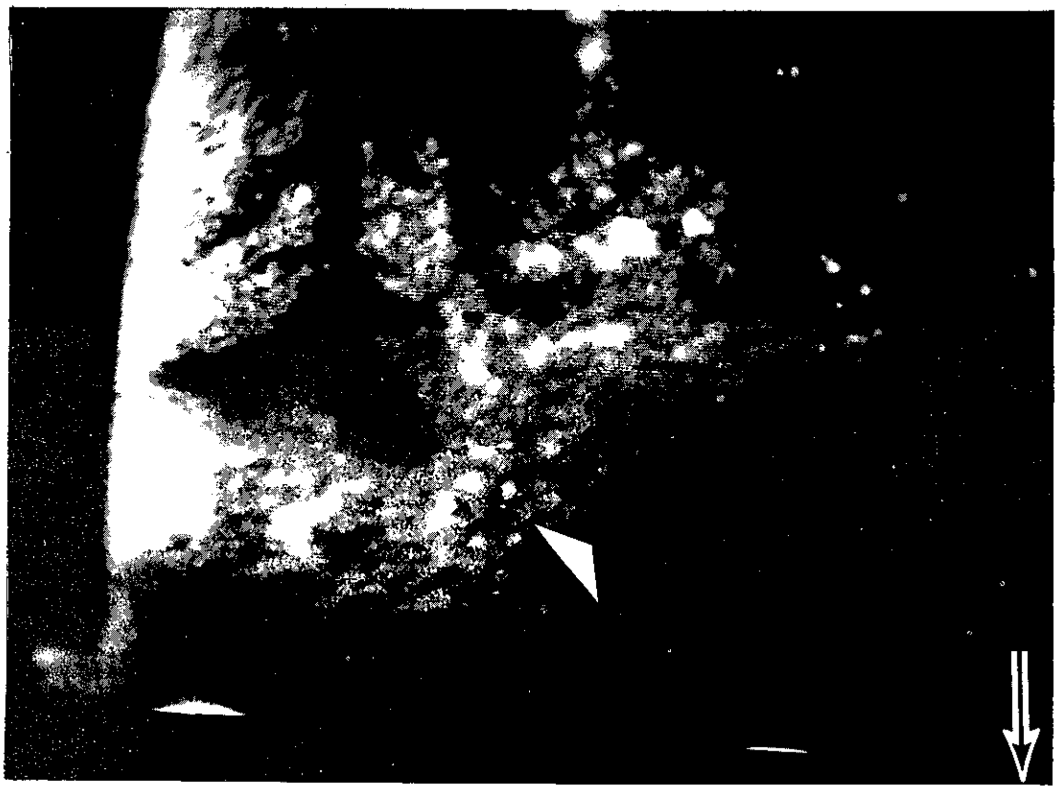


Photo 9 - Boring R-8 Santa Susana Pass 42.7 ft. Void and fracture in sandstone. Lost circulation during drilling.

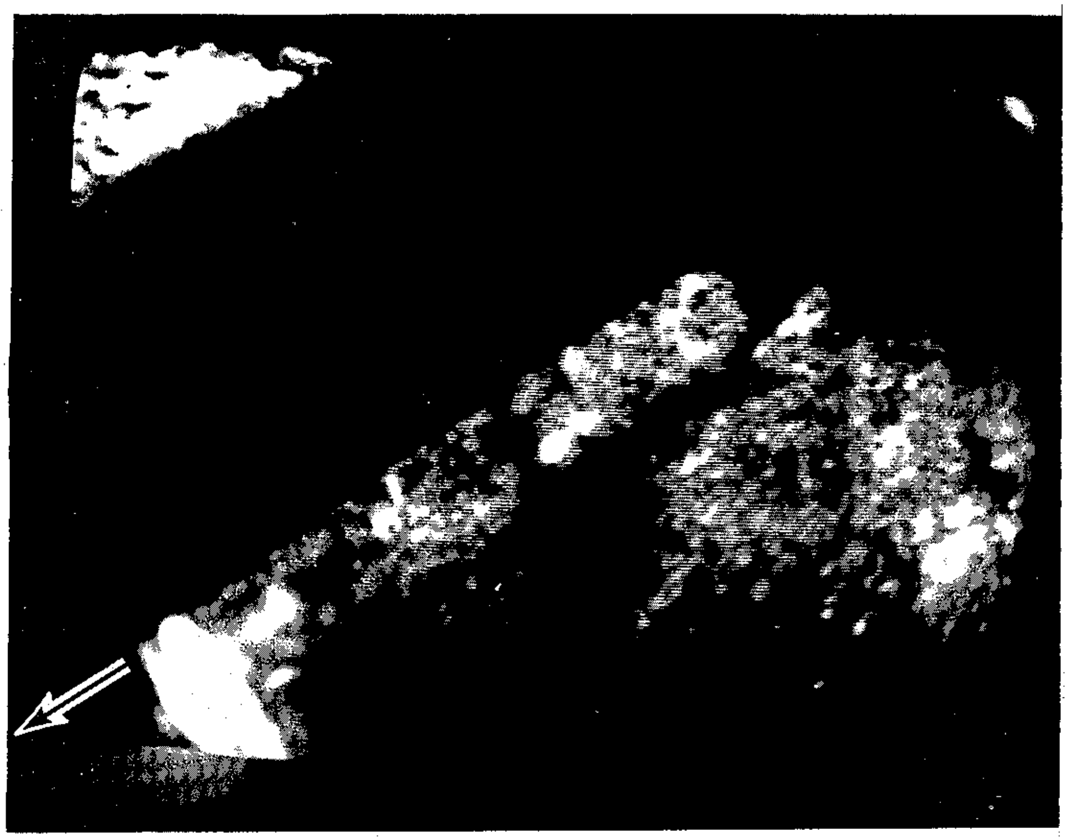


Photo 10 - Boring R-8 Santa Susana Pass 49.3 ft. Vertical fracture in sandstone.

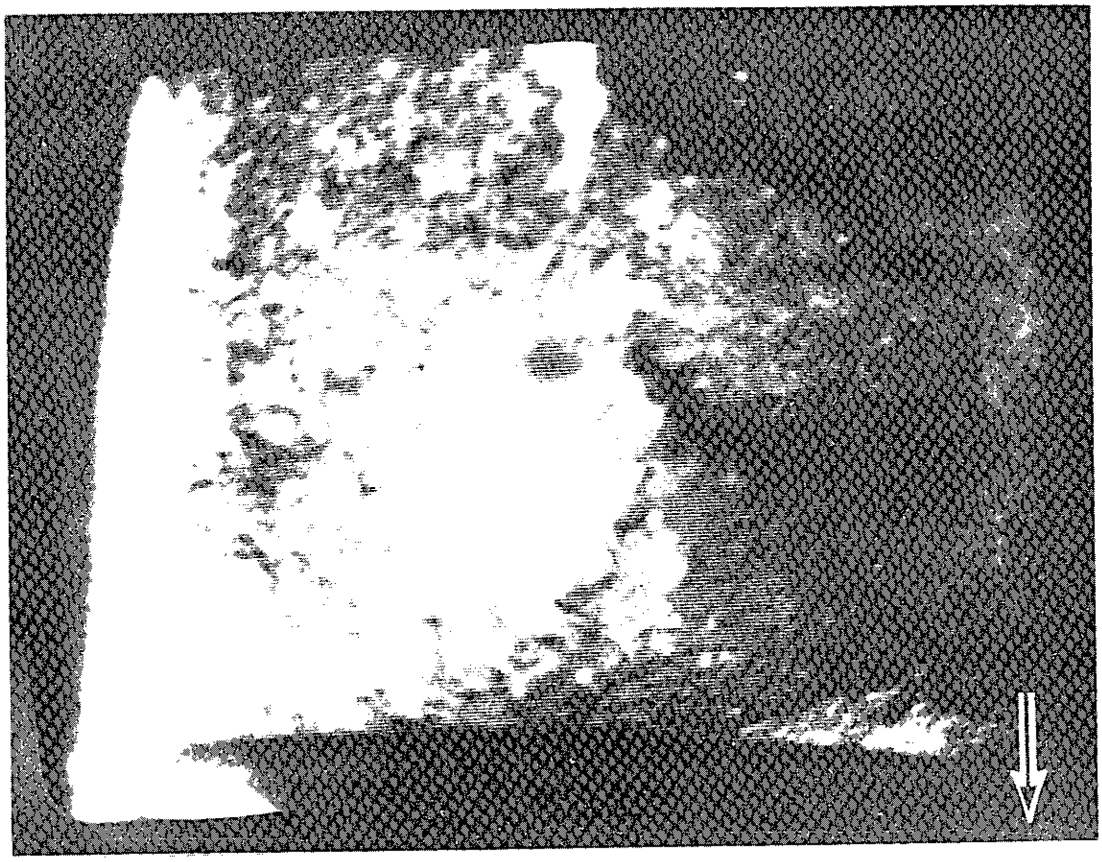


Photo 11 - Boring R-8 Santa Susana Pass 48.3 ft. Large void in sandstone.

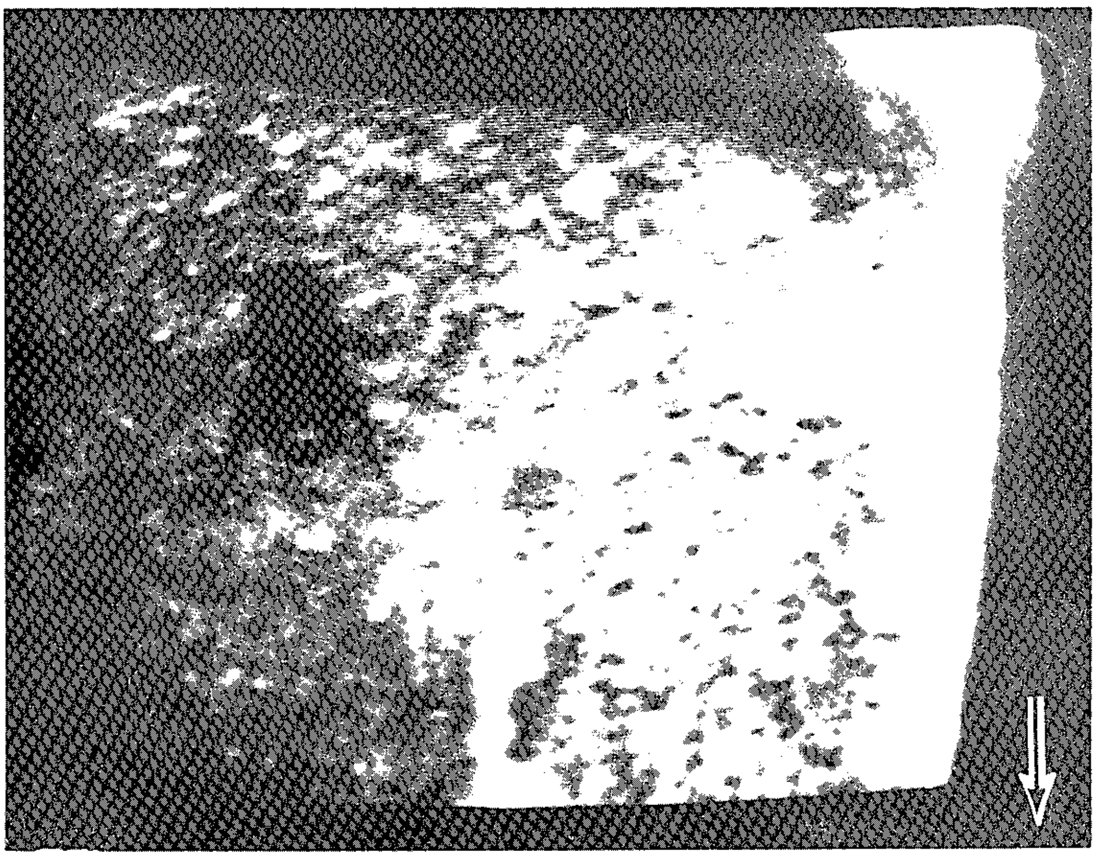


Photo 12 - Boring R-8 Santa Susana Pass 52.4 ft. Beetle on wall of boring. Beetle is about .6 inch long.

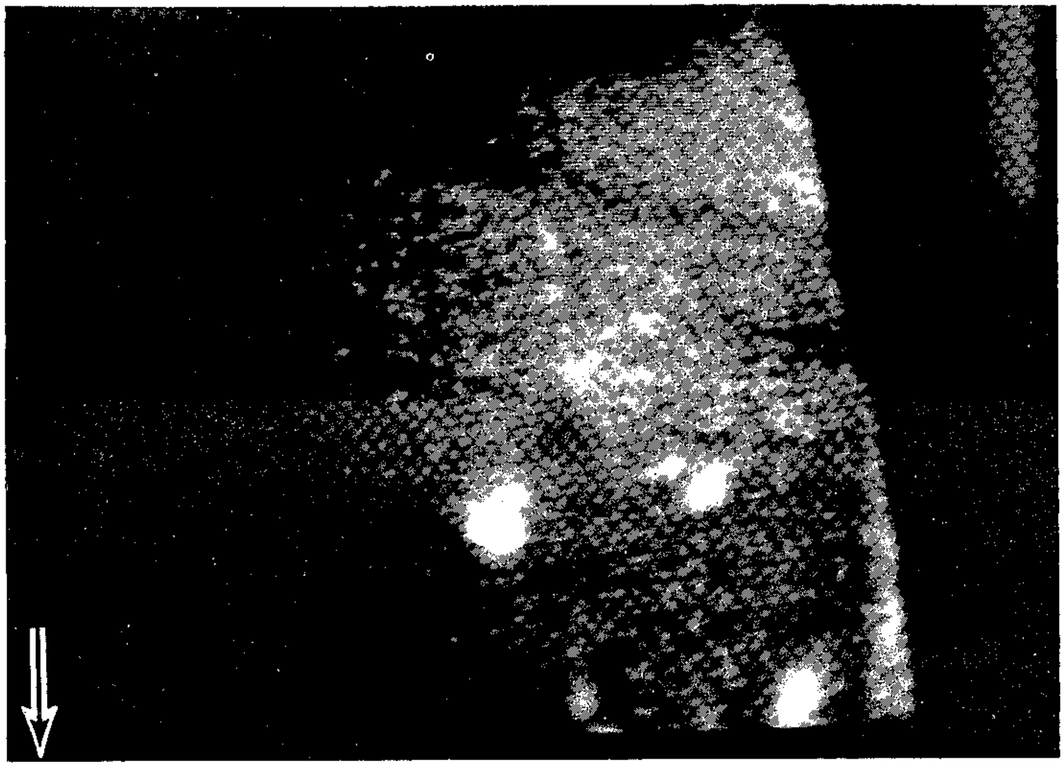


Photo 13 - Boring R-15 Santa Susana 9.8 ft. Laminations in sandstone. Strike N44E, dip 45°W.

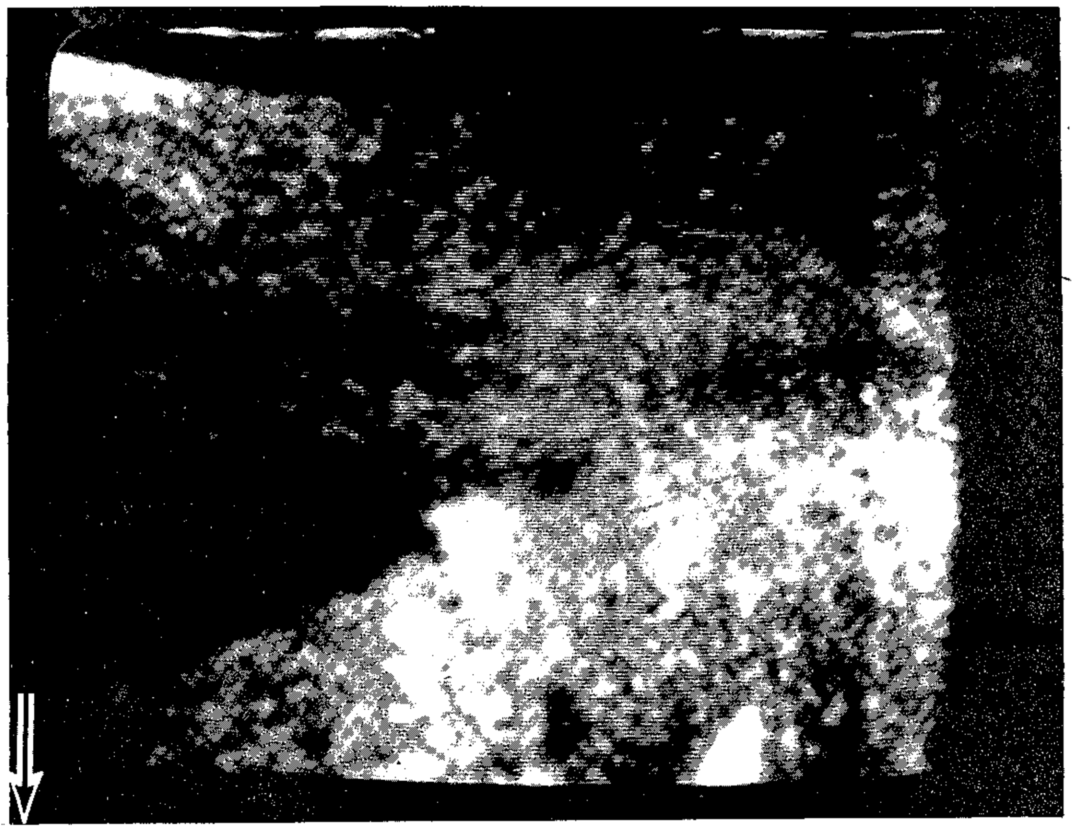


Photo 14 - Boring R-15 Santa Susana Pass 55.0 ft. 0.2 inch wide shale bed in sandstone strike N53E.

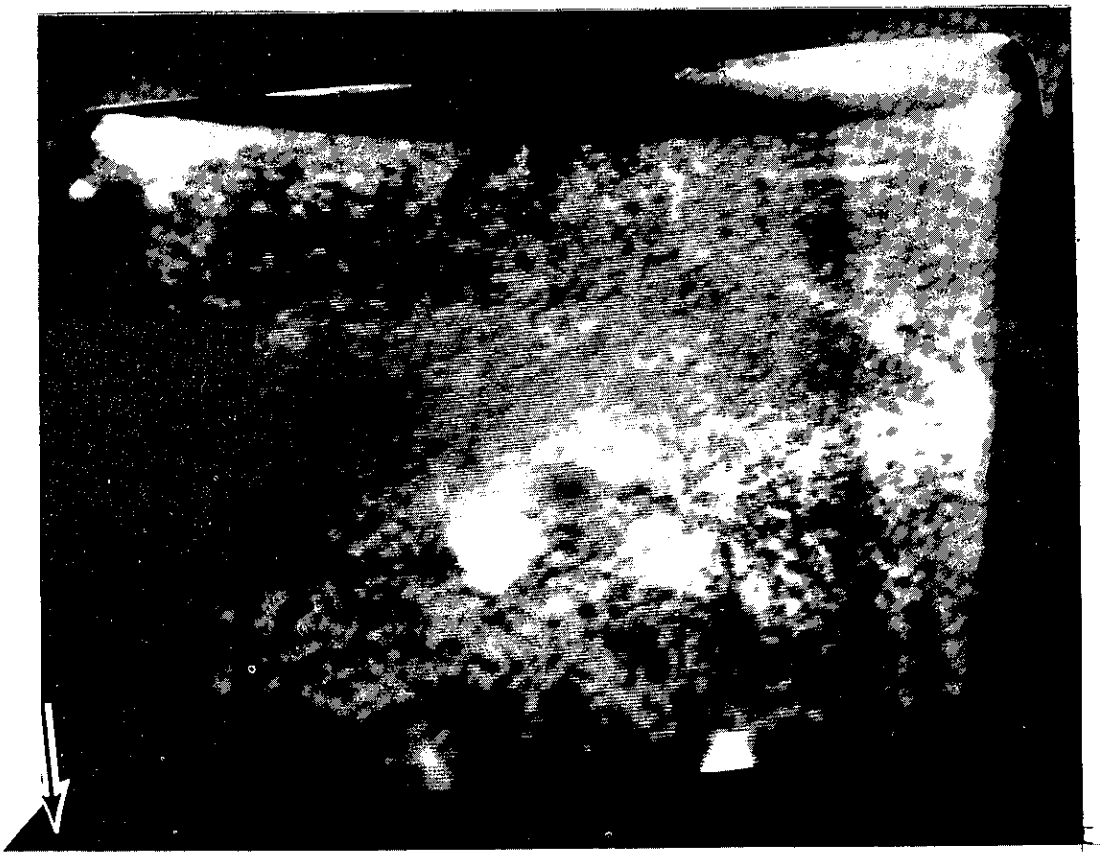


Photo 15 - Boring R-15 Santa Susana Pass 62.5 ft. Texture contrast - gray fine-grained sandstone to brown coarse-grained sandstone.

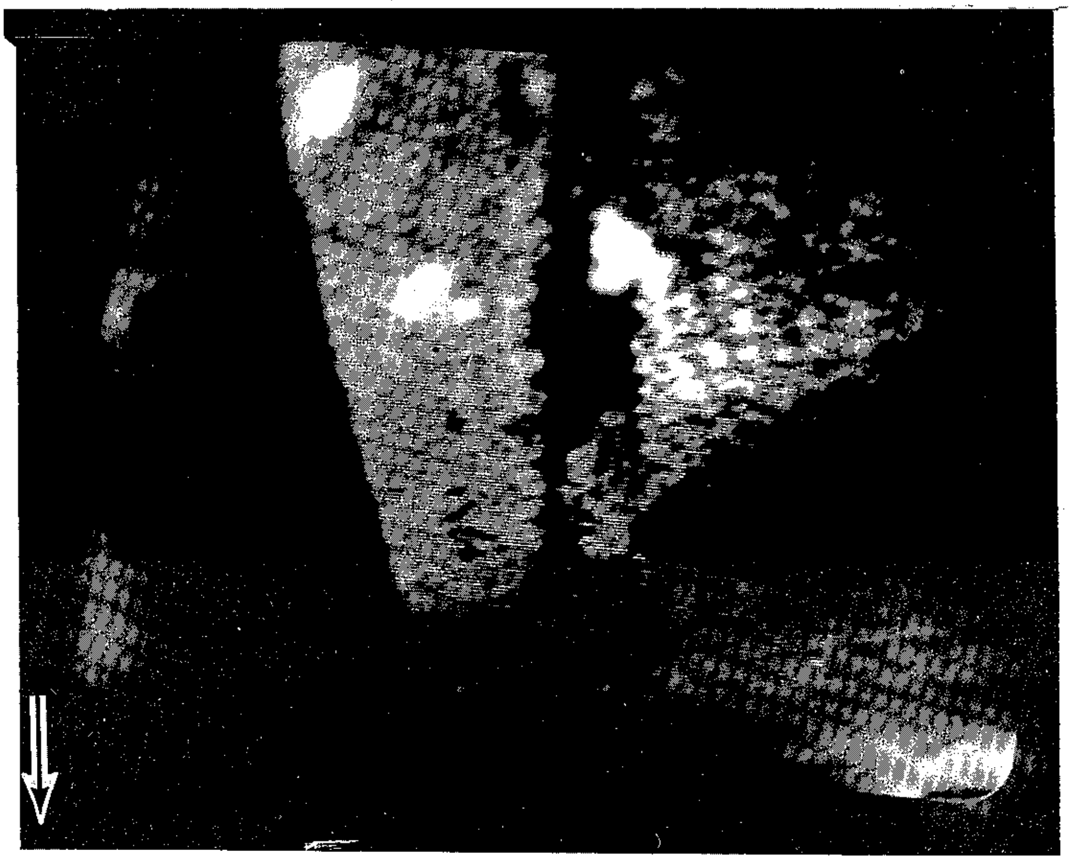


Photo 16 - Boring R-15 Santa Susana Pass 28.7 ft. Large fracture in sandstone (approximatelv 0.2 inch wide). Lost circulation during drilling.

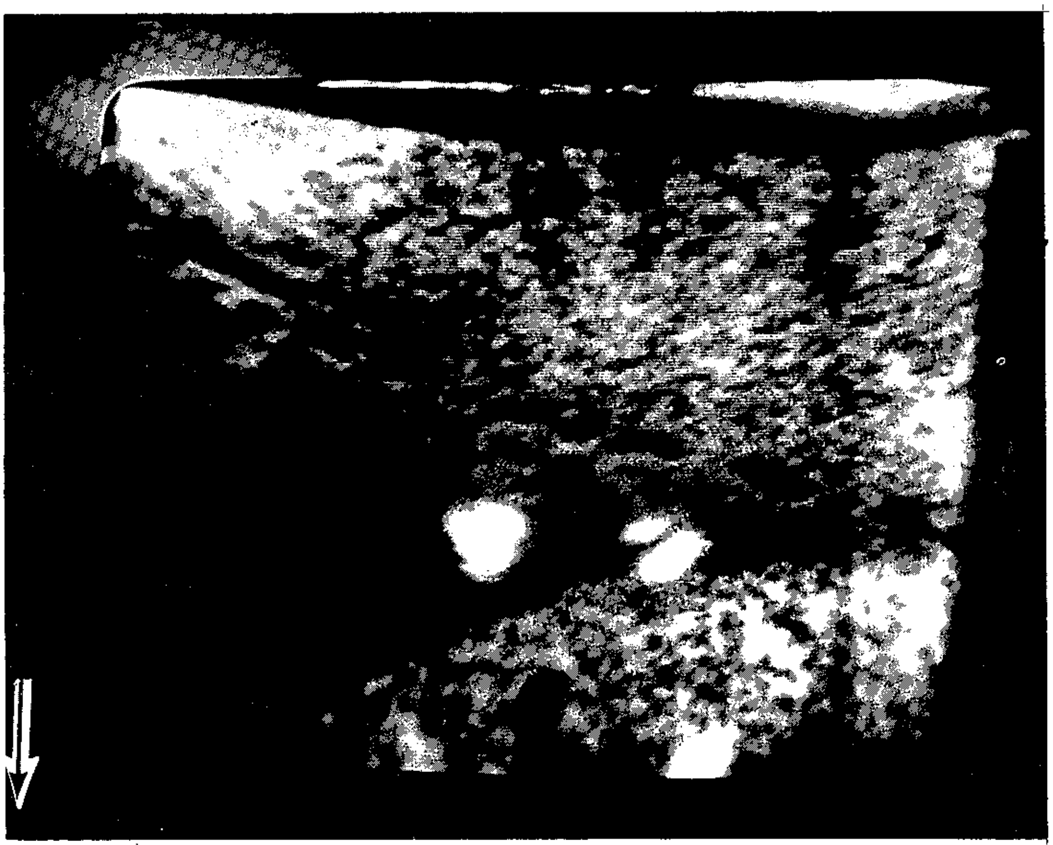


Photo 17 - Boring R-15 Santa Susana 81.0 ft. Dipping fracture in sandstone with associated voids.

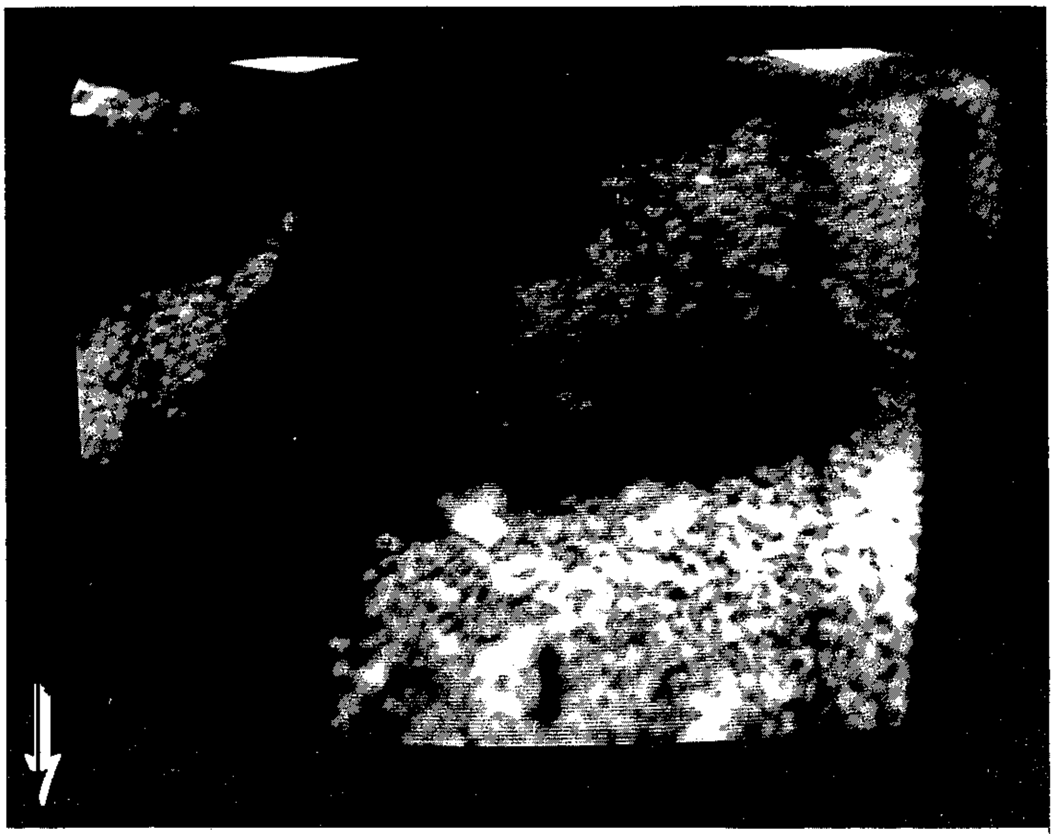


Photo 18 - Boring R-15 Santa Susana 87.9 ft. Large void (about 0.5 inch at narrowest point) in sandstone. N83E.

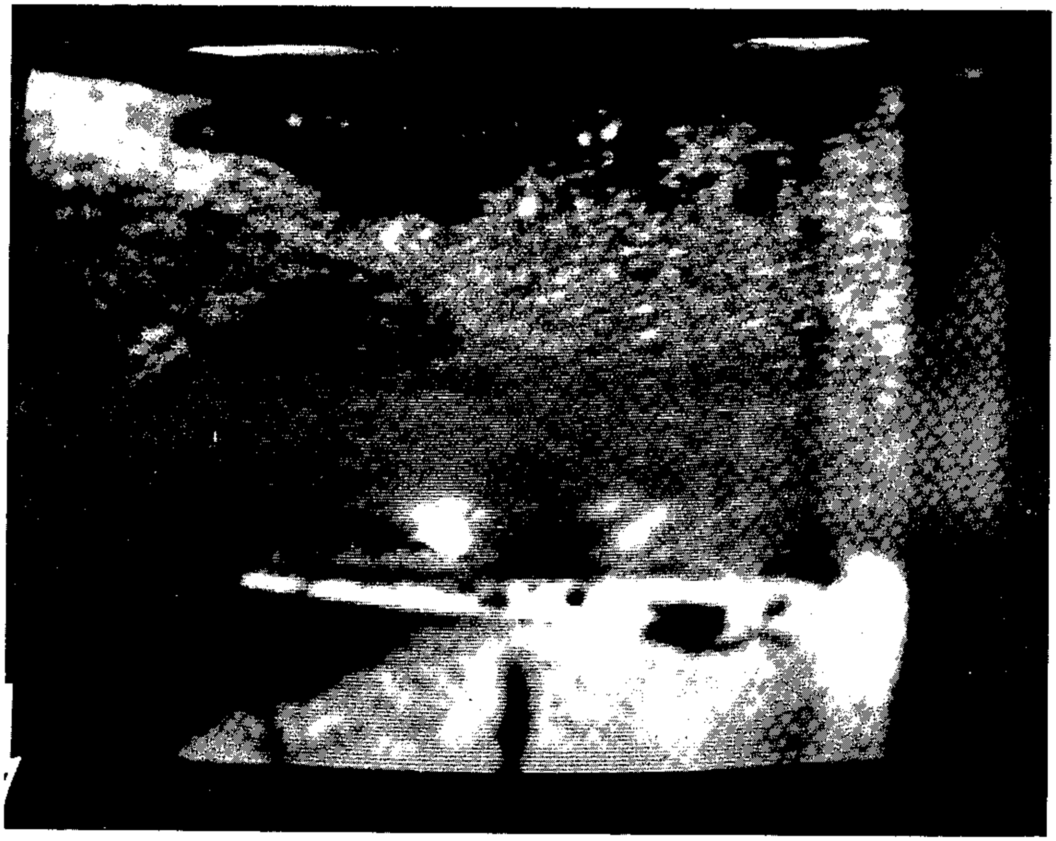


Photo 19 - Boring R-15 Santa Susana Pass 90.0 ft. Water table with dark organic fragments floating on surface.

Photo 20 - Boring R-6 Anderson Grade 29.3 ft. Patches of mud cake (light areas) on walls of broken fractures.

Photo 21 - Boring R-6 Anderson Grade 98.9 ft. Steeply dipping parallel fractures (approximately 80°) in greenstone.

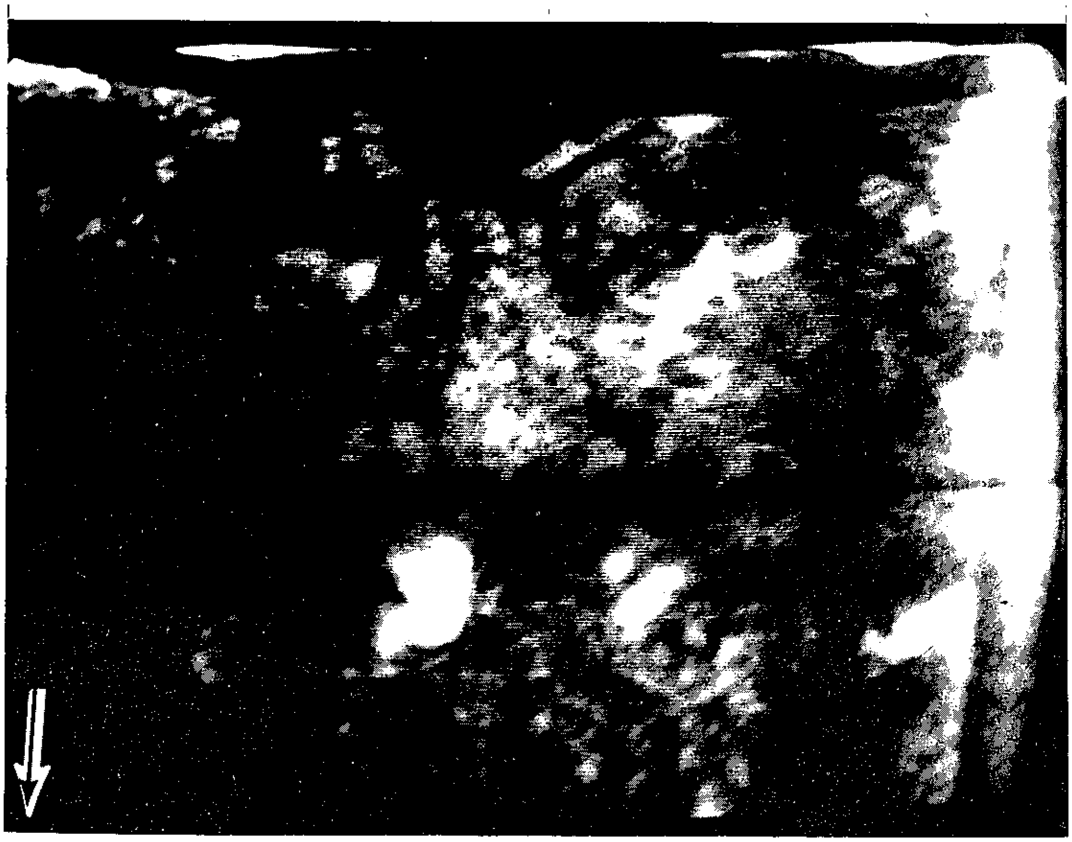


Photo 22 - Boring R-6 Anderson Grade 110.0 ft. Fractured greenstone with chips plucked from wall by drill bit.

Photo 23 - Boring R-6 Anderson Grade 47.4 ft. Severely fractured greenstone healed with $CaCO_3$.

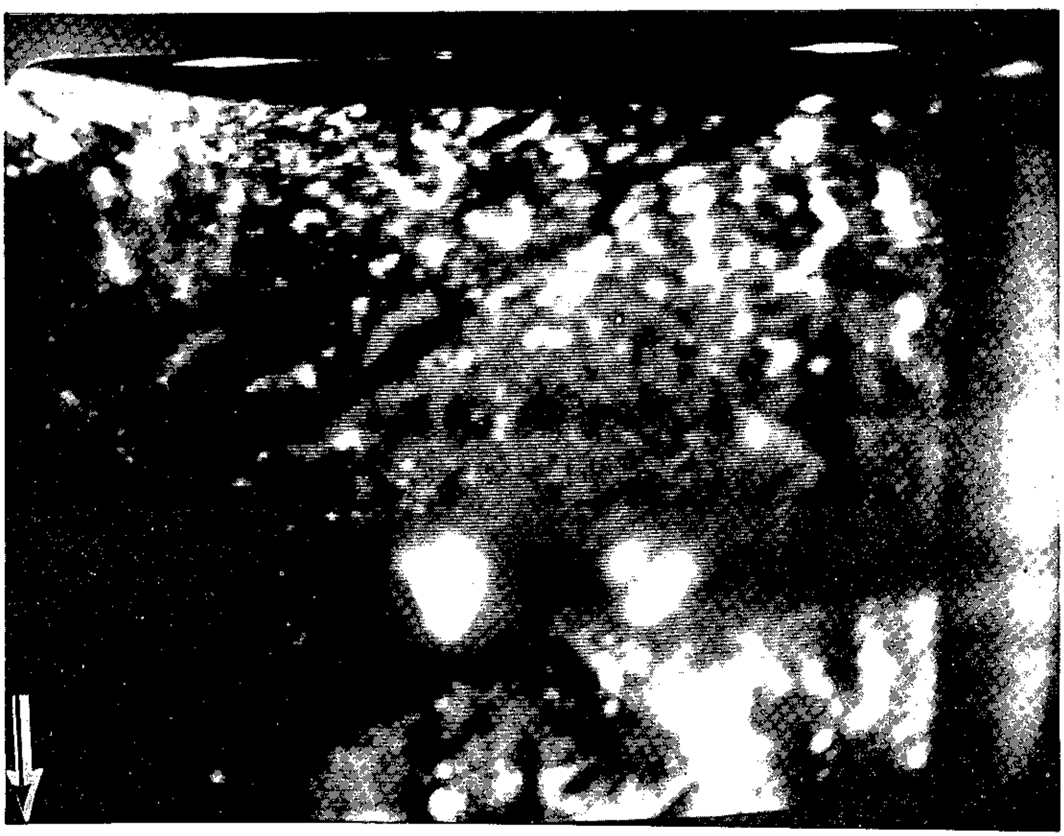


Photo 24 - Boring R-5 Anderson Grade 71.2 ft. 45° fractures in greenstone. Very wet walls.

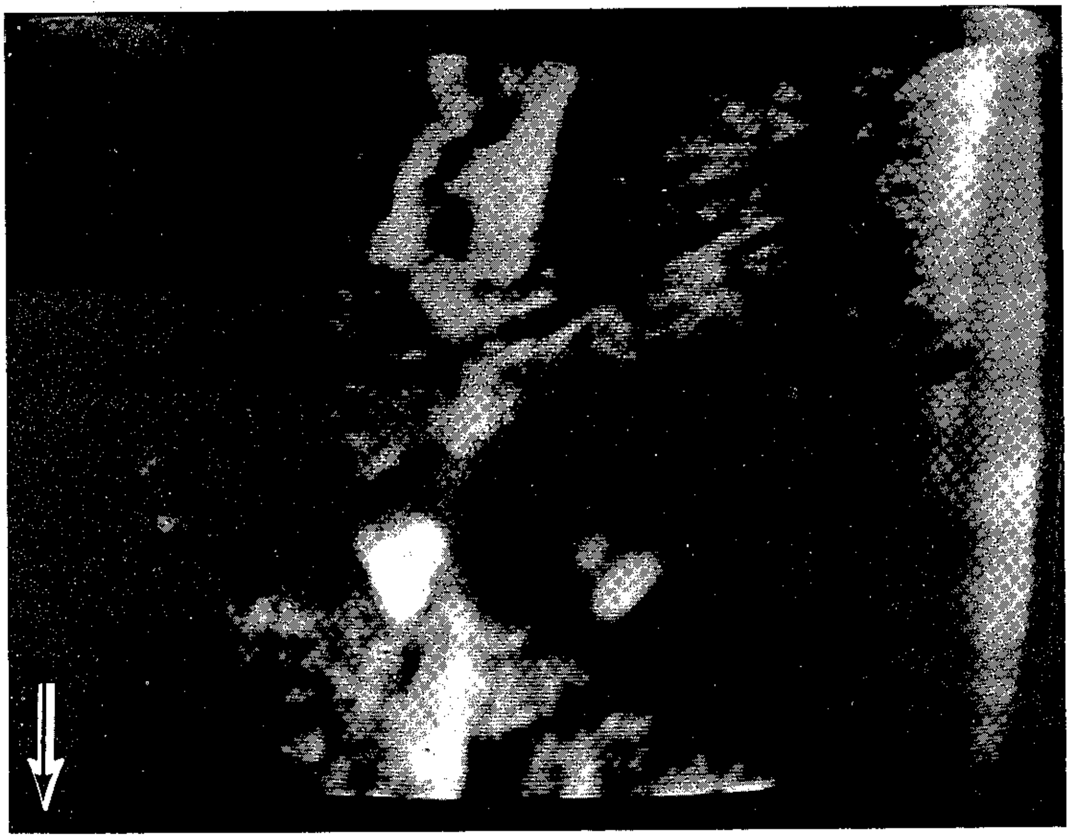


Photo 25 - Boring R-5 Anderson Grade 29.8 ft. ½-inch quartz vein cut by slickensided fracture.

Photo 26 - Boring R-5 Anderson Grade 33.7 ft. Fractured zoned greenstone healed with $CaCO_3$. Some mud cake on walls.

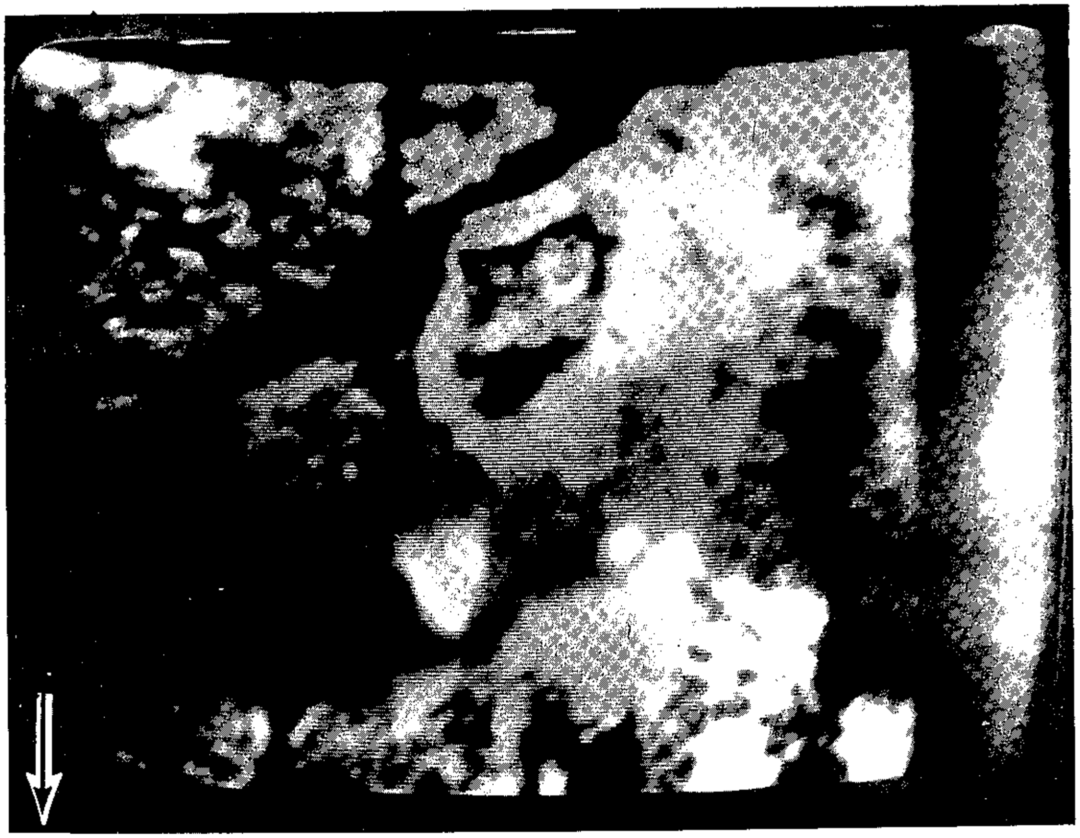


Photo 27 - Boring R-5 Anderson Grade 39.8 ft. Large open fracture in greenstone. Light areas are mud cake.

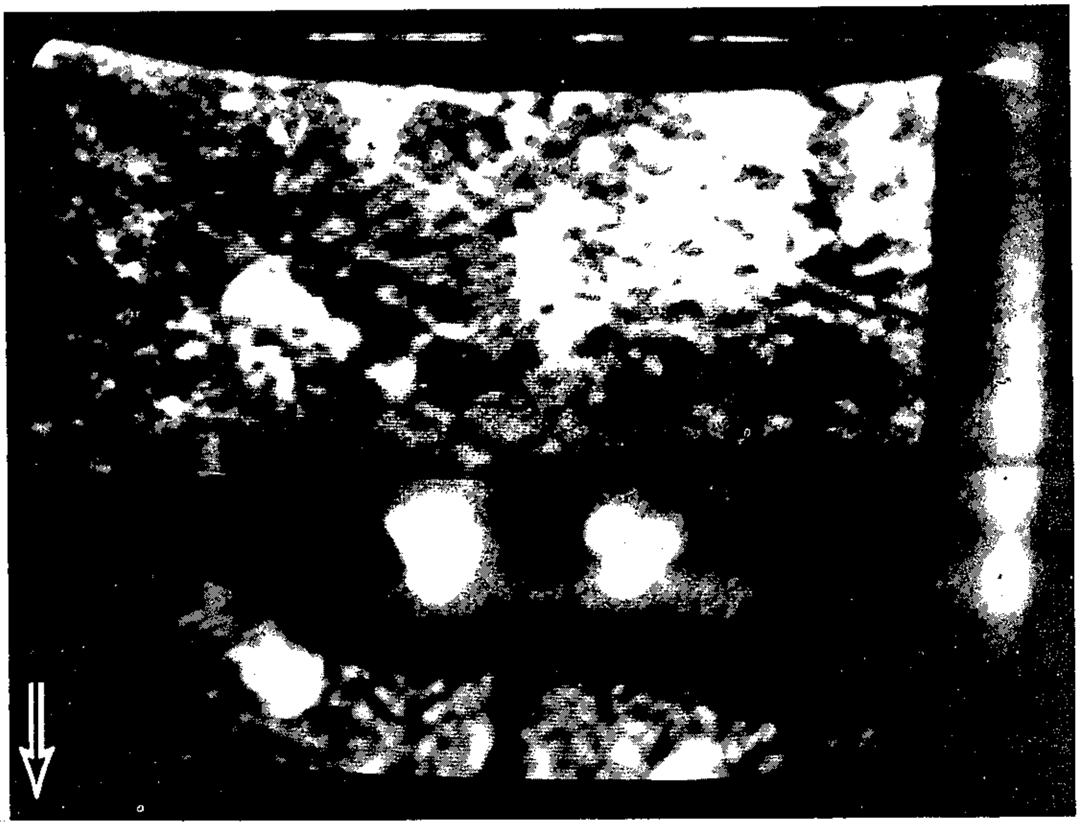


Photo 28 - Boring R-5 Anderson Grade 61.8 ft. Fracture dipping 50° in greenstone.

Photo 29 - Boring R-5 Anderson Grade 154.5 ft. $CaCO_3$ filled fracture dipping 40°. Dark band is shadow of post in camera probe.

Photo 30 - Boring R-5 Anderson Grade 160.3 ft. Circular fracture healed with calcite.

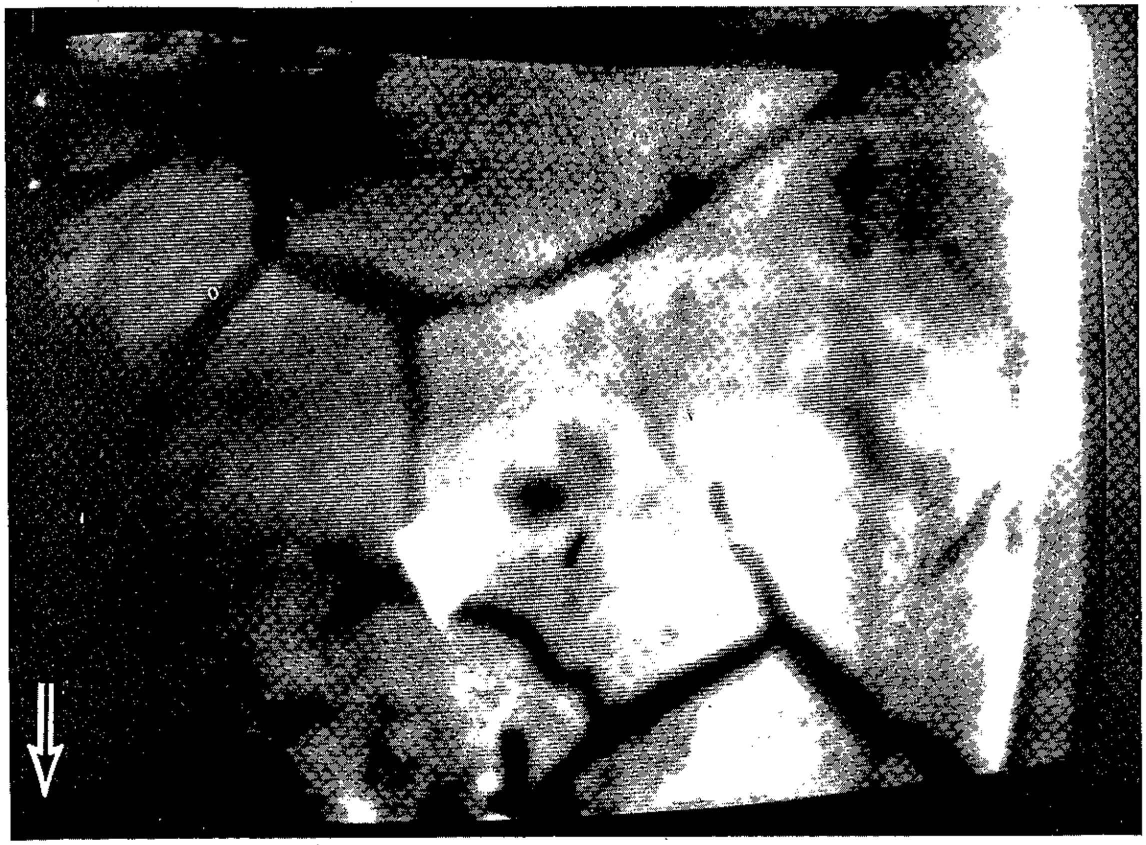


Photo 31 - Boring R-5 Anderson Grade 6.3 ft. Cracks in mud cake on boring wall.

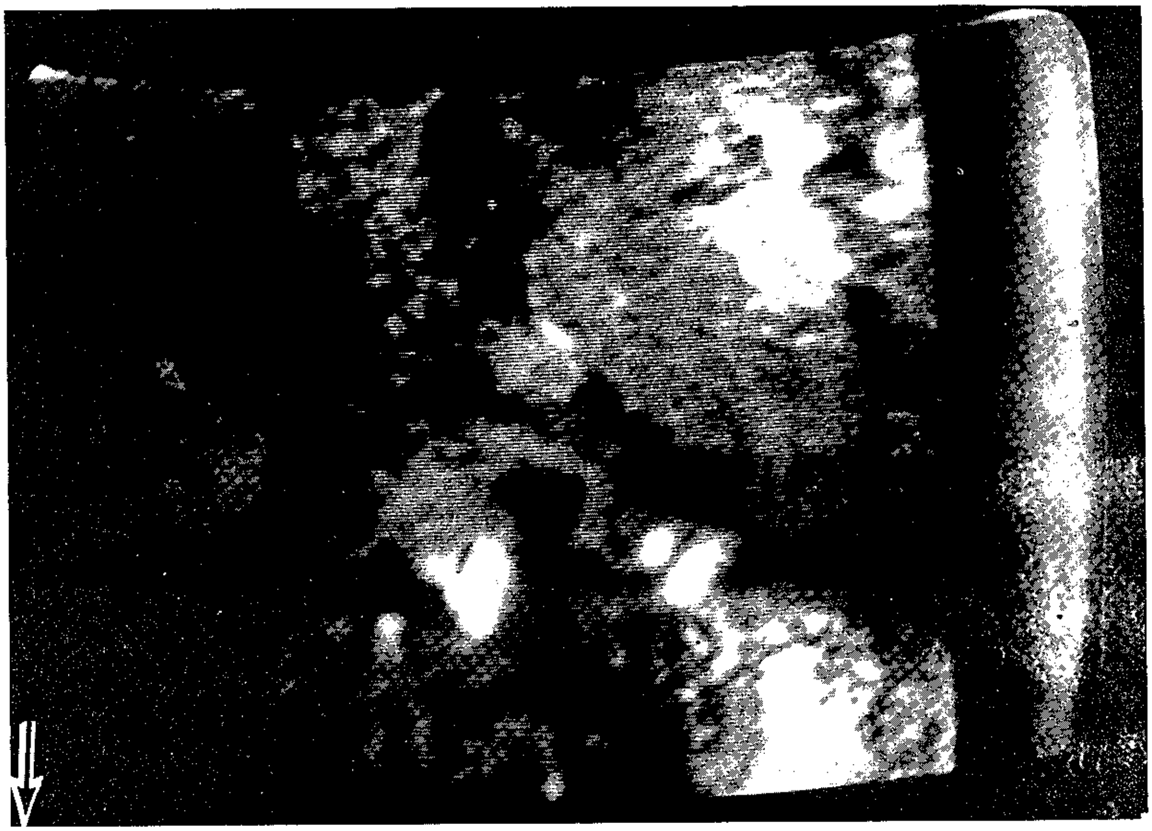


Photo 32 - Boring R-4 Anderson Grade 34.2 ft. Large open fractures in greenstone.

Photo 33 - Boring R-4 Anderson Grade 48.5 ft. Jagged fracture on wet wall of greenstone, dipping approx. 35°. Post of camera in photo.

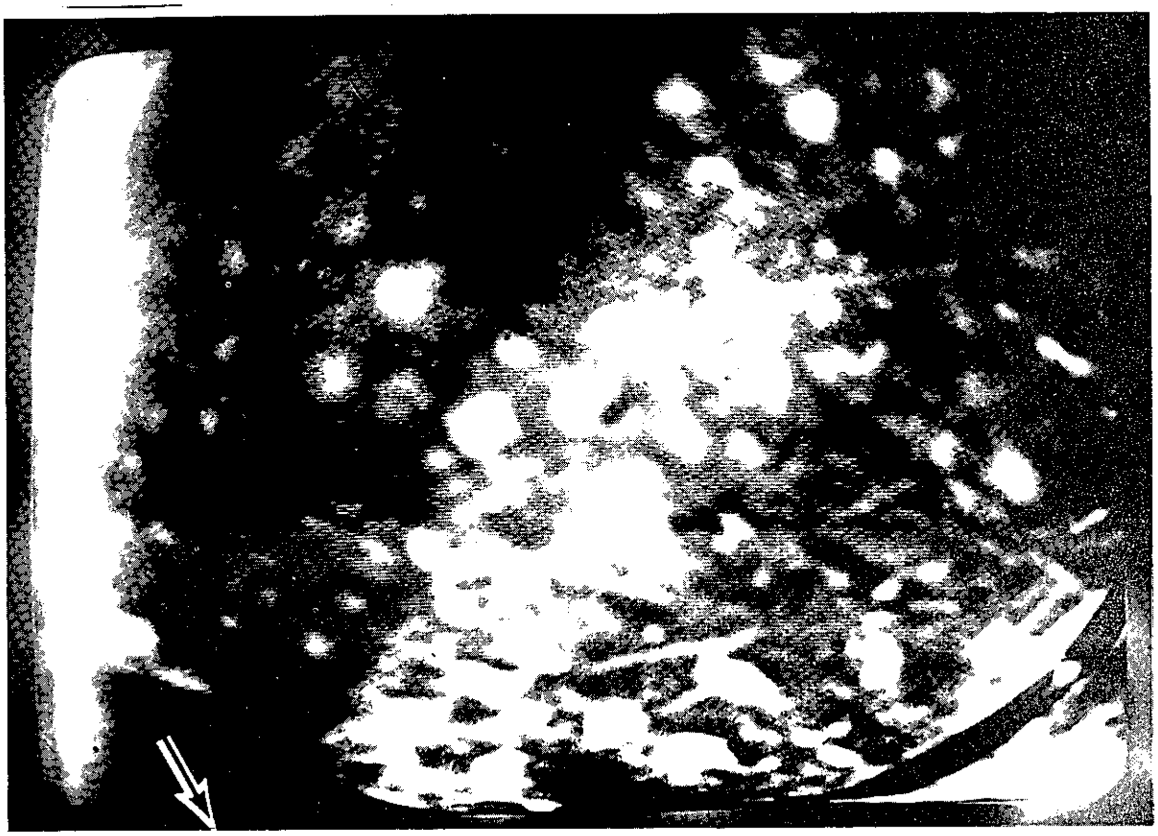


Photo 34 - Boring R-4 Anderson Grade 82.6 ft. Amygdules of $CaCO_3$ in greenstone.

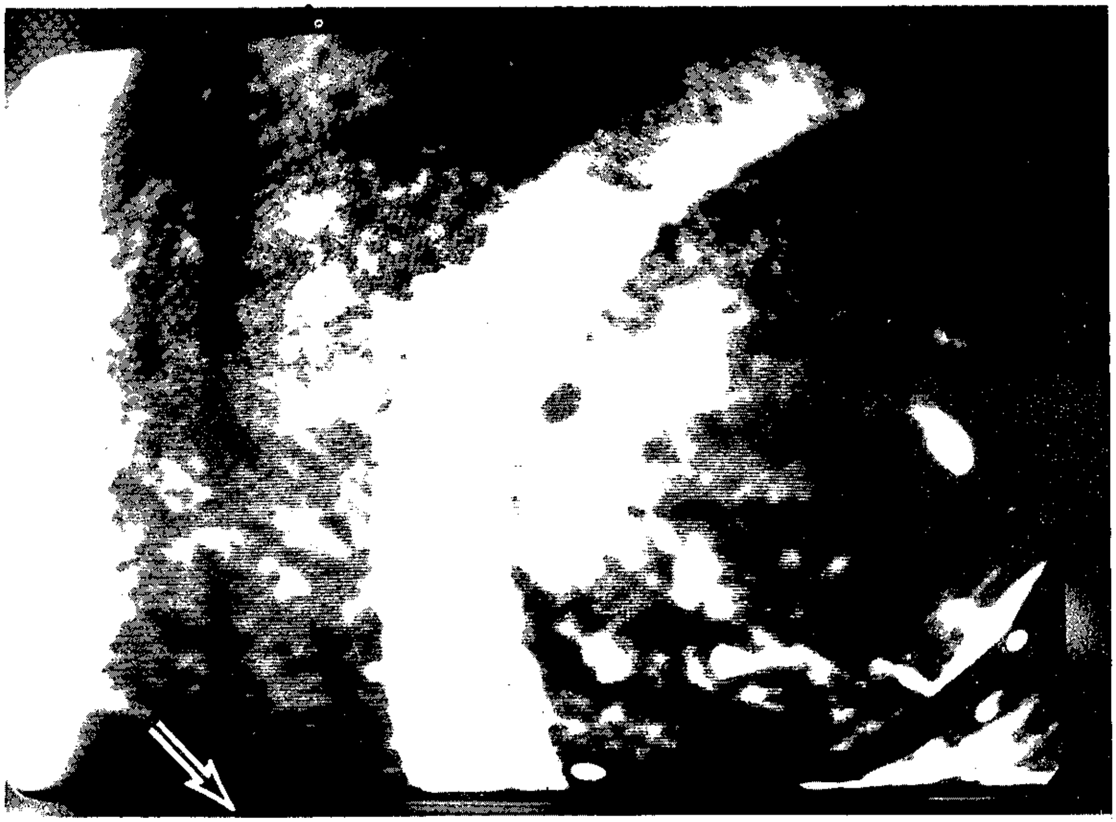


Photo 35 - Boring R-4 Anderson Grade 141.8 ft. ½-inch calcite vein in greenstone.

Photo 36 - Boring B80 City of Yreka 44.4 ft. Light colored clay seams in sheared serpentine.

Photo 37 - Boring B80 City of Yreka 48.8 ft. Clay seam dipping 5° in sheared serpentine. Note 70° joint in center of photo.

Photo 38 - Boring B79 City of Yreka 6.6 ft. Large cavity plucked from wall by drill bit.

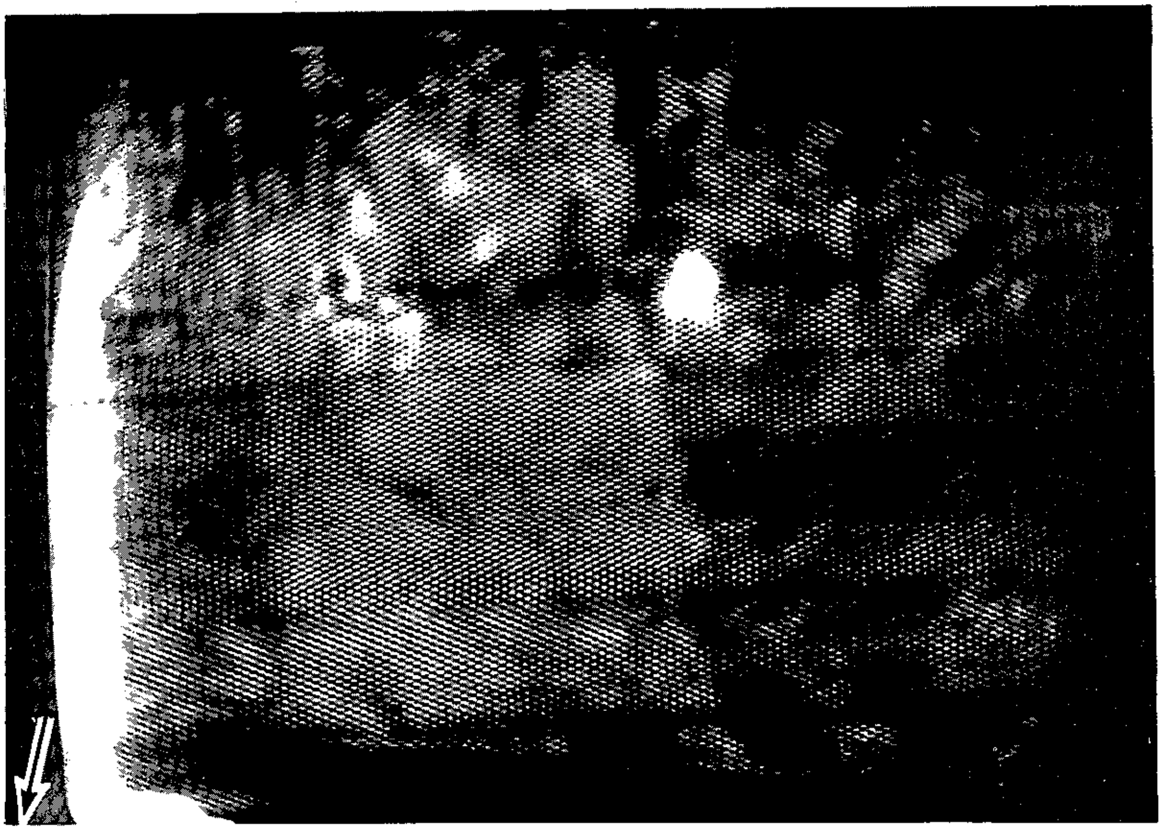


Photo 39 - Boring B79 City of Yreka 33.4 ft. Fractured serpentine. Grid pattern due to electronic difficulties in camera probe and monitoring unit.